GUIDANCE FOR HUMAN INTERFACE WITH ARTIFICIAL INTELLIGENCE SYSTEMS

Scott S. Potter and David D. Woods

Cognitive Systems Engineering Laboratory
Department of Industrial and Systems Engineering
The Ohio State University
Columbus, Ohio 43210

Research and experience with artificial intelligence (AI) systems has shown that the interaction of the intelligent system with human users and problem solvers is a critical element in the success and effectiveness of AI system development for real world applications[1]. Performance breakdowns can occur, for example, in situations where the intelligent system interface does not support the problem solving approach of the human operator[2]. Thus, there is a need to integrate human and machine problem solvers into an effective cooperative system[3]. This requires serious consideration of the human interface to AI systems during the design of intelligent systems.

A body of knowledge and guidance about how to integrate intelligent computer power and human practitioners has recently begun to accumulate. Empirical studies of human-human cooperative problem solving[4,5], empirical studies of human-intelligent computer cooperation[6], new research concepts for intelligent support systems[7,8] have contributed to the growth of this body of knowledge. In addition, systems builders and users, who have realize how poor human-intelligent system interfaces can retard cooperative problem solving, are experimenting with new ideas for more sophisticated interfaces to AI systems[9].

More effective AI systems can be developed if we collect, organize, and meaningfully deliver this knowledge to AI system designers[10]. However, there are several obstacles to meeting this objective. First, the state of research on effective human-intelligent computer interaction and cooperation is diffuse. There is a need to gather together, integrate, and assess the research results.

Second, there are cases of intelligent system development where designers and users are trying out new ideas about the human interface to AI systems, especially within NASA. Examining specific cases of both successful and unsuccessful AI system development with respect to human interface capabilities is a critical activity[11]. Collecting and assessing this experience will help expand and clarify the research base on what is effective human-intelligent computer cooperation.

Once integrated, this knowledge base will prove to be immature. There are gaps, ambiguities, and contradictions in the literature and practical experience. Thus, third, there is a need to conduct empirical studies that examine specific concepts about human-intelligent system cooperation related to actual cases of AI system development.

Fourth, one of the fundamental points of research on human-machine cooperative problem solving is that the concepts for how the machine will assist the person can strongly constrain the architecture and design of the machine itself[2]. In the typical design paradigm, one first develops (or independently develops) an autonomous machine problem solver and, only then, one thinks about how the person will use the machine to achieve better performance. Generally, the result has been that the design of the machine has not made allowances for features that turn out to be critical for people to make effective use of the system's capabilities[6]. It is critical, at the design concept stage, to consider how the person will use the machine to achieve better performance so that the inter-constraints between human interface design requirements and intelligent system design requirements can both be satisfied.

This means that a dialogue is needed between researchers in AI (whose research question is how

to build better performing machines) and researchers in human-intelligent computer interaction (whose research question is how to use machine power to assist human problem solving). Understanding effective human-intelligent computer interaction is incomplete if it cannot be achieved through practical AI techniques and tools that are available for the development of real world systems which include AI. Consequently, there is a need to consider the interaction between concepts for more effective human-intelligent computer interaction, their implications about aspects of AI systems, and current techniques for building real world AI systems.

Fifth, research results alone do not constitute good advice for designers. The problem of preparing effective guidelines for designers and delivering that guidance in a form that can be used by designers (aiding design) is a substantive problem regardless of the topic of the guidance. One has only to look at existing guideline documents in the area of human-computer interaction to find many examples that have proven less than satisfactory[12,13]. Thus, there is the need to examine how AI systems are designed[14] in order to deliver the right kind of knowledge in a form that designers can really use.

We are beginning a research effort to collect and integrate existing research findings about how to combine computer power and people, including problems and pitfalls as well as desirable features. The goal of this research project is to develop guidance for the design of human interfaces with intelligent systems. Fault management tasks in NASA domains are the focus of the investigation. Research is being conducted to support the development of guidance for designers that will enable them to take human interface considerations into account during the creation of intelligent systems.

The research will examine previous results, NASA cases of AI system development, and conduct new studies of human-intelligent system cooperation focusing on issues such as: (1) how to achieve effective advice, (2) how to create a shared representation of the problem domain, (3) how to provide support for problem solving in situations requiring adaptation to unanticipated events, (4) what are appropriate levels of supervisory control, (5) the need for reasoning strategies consistent with those of the human operator and (6) what kinds and forms of explanation will support human-intelligent system cooperation.

The body of results on what interface and AI system capabilities support effective human-AI system cooperation in fault management tasks will be used to develop guidance for designers. The goal is to help designers take human interface considerations into account during the creation of

intelligent systems. The results will provide advice about what kinds of information produced by an intelligent system should be made available to its human partners and advice about how to organize and display the intelligent system's situation assessment and response plan as well as information on the underlying process itself.

References

1. Hollnagel, E., Mancini, G., and Woods, D. (Eds.), INTELLIGENT DECISION SUPPORT IN PROCESS ENVIRONMENTS. Springer-Verlag, New York, 1986.

2. Roth, E. M. and Woods, D. D., "Cognitive task analysis: An approach to knowledge acquisition for intelligent system design", in G. Guida and C. Tasso (Eds.), TOPICS IN EXPERT SYSTEM DESIGN, North Holland, New York, 1989.

3. Woods, D. D. and Roth, E. M., "Cognitive Systems Engineering", In M. Helander (Ed.), HANDBOOK OF HUMAN-COMPUTER INTERACTION, North-Holland, New York, 1988, pp. 1-43.

4. Coombs, M. and Alty, J., "Expert systems: An alternative paradigm", INTERNATIONAL JOURNAL OF MAN-MACHINE STUDIES, 20, 1984, pp. 21-43.

5. Carroll, J. M. and McKendree, J., "Interface design issues for advice-giving expert systems", COMMUNICATIONS OF THE ACM, 30, 1987, pp. 14-31.

6. Roth, E. M., Bennett, K. B., and Woods, D. D., "Human interaction with an 'intelligent' machine", INTERNATIONAL JOURNAL OF MAN-MACHINE STUDIES, 27, 1987, pp. 479-525.

7. Woods, D. D. and Elias, G., "Significance messages: An integral display concept", IN PROCEEDINGS OF THE HUMAN FACTORS SOCIETY, 32ND ANNUAL MEETING, The Human Factors Society, Santa Monica, CA, 1988.

8. Fischer, G., Lemke, A. and Mastaglio, T., "Using critics to empower users", In PROCEEDINGS OF THE CHI'90 HUMAN FACTORS IN COMPUTING SYSTEMS CONFERENCE, Association for Computing Machinery, New York, 1990.

9. Muratore, J. F. et al., "Real time expert system prototype for Shuttle mission control", PROCEEDINGS OF THE 2ND ANNUAL WORKSHOP ON SPACE OPERATIONS, AUTOMATION AND ROBOTICS, NASA, 1988

10. Malin, J. T., "Framework for developing ICAPS (Intelligent Computer-Aided Problem Solving) systems for space operations", AAAI SPRING SYMPOSIUM ON KNOWLEDGE BASED HUMAN-COMPUTER COMMUNICATION, AAAI, 1990.

11. Remington, R. W. and Shafto, M. G. "Building human interfaces to fault diagnostic expert systems: I. Designing the human interface to support cooperative fault diagnosis." Workshop on Human-Computer Interaction in Aerospace Systems, CHI'90 Human Factors in Computing Systems Conference, SIGGRAPH, ACM, 1990.

12. Smith, S. L., "Standards versus guidelines for designing user interface software", In M. Helander (Ed.), HANDBOOK OF HUMAN-COMPUTER INTERACTION, North-Holland, New York, 1988, pp. 877-889.

13. Woods, D. D. and Eastman, M. C., "Integrating principles for human-computer interaction into the design process", In PROCEEDINGS OF THE IEEE INTERNATIONAL CONFERENCE ON SYSTEMS, MAN, AND CYBERNETICS, IEEE, 1989.

14. Malin, J. T. and Lance, N., "Process in construction of failure management expert systems from device design information", IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS, SMC-17 (11), 1987, pp. 956-967.